

MICROBIAL GROWTH IN A HUMIC-FREE ENVIRONMENT ON THE COTTON GLACIER, ANTARCTICA

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INTRODUCTION

During the summer of 2004-2005, we sampled a supraglacial stream that forms on the Cotton Glacier in the Transantarctic Mountains (Figure 1). Analysis by fluorescence spectroscopy of dissolved organic matter (DOM) from this stream showed that the concentration was low (44-48 $\mu\text{M C}$), and lacked humic signatures, unlike DOM typical of microbially-based ecosystems.

In most aquatic ecosystems, humic DOM acts as a natural sunscreen and the absence of humics may represent an additional stressor influencing the microbial community. Nonetheless, the stream contained an active microbial assemblage with bacterial cell abundances from 2.94×10^4 – 4.97×10^5 cells ml^{-1} , and bacterial production ranging from 58.8-293.2 ng $\text{C l}^{-1} \text{d}^{-1}$. Chlorophyll-a concentrations ranged from 0.3 to 0.53 mg l^{-1} indicating that algal phototrophs were the probable source of the DOM.

Supraglacial streams provide an example of contemporary microbial processes on the glacier surface and a natural laboratory for studying the microbial adaptation to the absence of humics, as well as chemical processes controlling the eventual genesis of humic DOM.

STUDY SITE



Figure 1. USGS maps and a photo of the Cotton Glacier

The Cotton Glacier lies north of Cape Roberts (77° 07'S, 161° 40'E), flowing eastward between Sperm Bluff and Queer Mountain for ~16 km (Figure 1). It was discovered by Griffith Taylor and the Western Geological Party 1910-1913. The Cotton Glacier has a limited catchment area in the Clare and St. Johns ranges, but receives a large amount of sedimentary deposits of unknown origin (fluvial, glacial or aeolian). The bedrock geology is dominated by basement granite and Ferrar dolerite sills, with minor amounts of amphibolite and schist sandwiched between granite bodies.

MEET THE TEAM



Figure 2. Not pictured, Diane McKnight, Yo Chin & Chip Kilduff

WATER QUALITY

Table 1. Water quality parameters measured at 3 locations on the Cotton Glacier. ND= not detectable.

Location	DOC (mg l^{-1})	TN (mg l^{-1})	F ⁻ (mg l^{-1})	Cl ⁻ (mg l^{-1})	SO ₄ ²⁻ (mg l^{-1})	N-NH ₃ ($\mu\text{g l}^{-1}$)	N-NO ₃ ($\mu\text{g l}^{-1}$)	P-PO ₄ ($\mu\text{g l}^{-1}$)	DIC (mg C l^{-1})
CG1	0.5	0.1	0.02	0.6	0.5	4.2	27.	ND	0.6
	7	1	2	6	8		1		1
CG2	0.5	0.1	0.03	1.3	1.1	7.8	38.	5.4	0.9
	6	4	8	4	0		0		4
CG3	0.5	0.0	0.02	1.3	0.8	4.0	33.	ND	0.5
	3	8	0	1	7		9		1

Although microbes have been found to inhabit a wide range of permanently cold temperate environments in polar regions, alpine lakes, super-cooled cloud droplets and sea ice (Psenner and Sattler 1998; Abyzov et al., 2001; Sattler et al., 2001), no previous study has examined the geomicrobiology of supraglacial streams on a pristine Antarctic glacier.

Microbial isolates from the Cotton Glacier produced a rainbow of pigment colors (Fig. 3), suggesting adaptation to UV stress, and were similar to those from other cryogenic systems (Cytobacterium psychrophilum lineages, Fig. 4).



Figure 3. Pigments produced by microbial isolates from the Cotton Glacier.

Figure 4. Phylogenetic tree (neighbor-joining) showing the relationship of 5 Cotton Glacier (CG) isolates to representative bacterial 16S rDNA genes. GenBank accession numbers are given in parentheses. Bootstrap values ≥ 50 are shown.

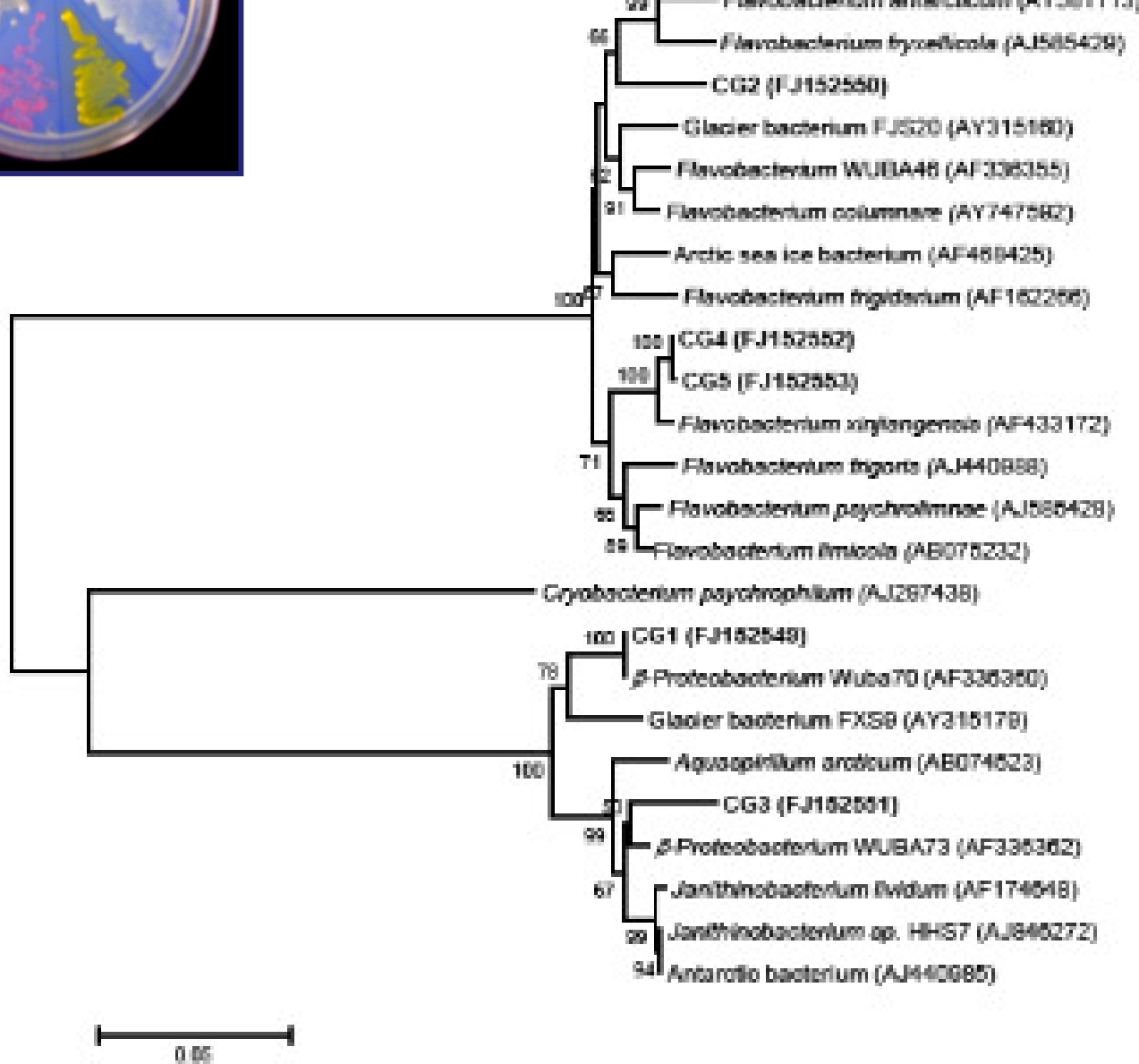


Table 2. Bacteria and Viral data from three sites on the Cotton Glacier

Location	Bacteria (Cells ml^{-1})	Bacterial Prod. ($\text{ng C ml}^{-1} \text{d}^{-1}$)	VLP (VLP ml^{-1})	V:B Ratio
CG1	4.97×10^5	1.61×10^7	1.08×10^4	0.02
CG2	2.94×10^4	5.35×10^6	1.06×10^4	0.43
CG3	1.19×10^5	2.67×10^7	1.36×10^4	0.11

The supra-glacial stream contained an active community with higher abundances and productivity at the two stream sites with sediment present (CG1 and CG3, Table 2). There were measureable concentrations of chlorophyll-a in all three samples, indicating the presence of algal species in the flowing water and more generally an autotrophic community that could be a source of the DOM.

CHEMISTRY

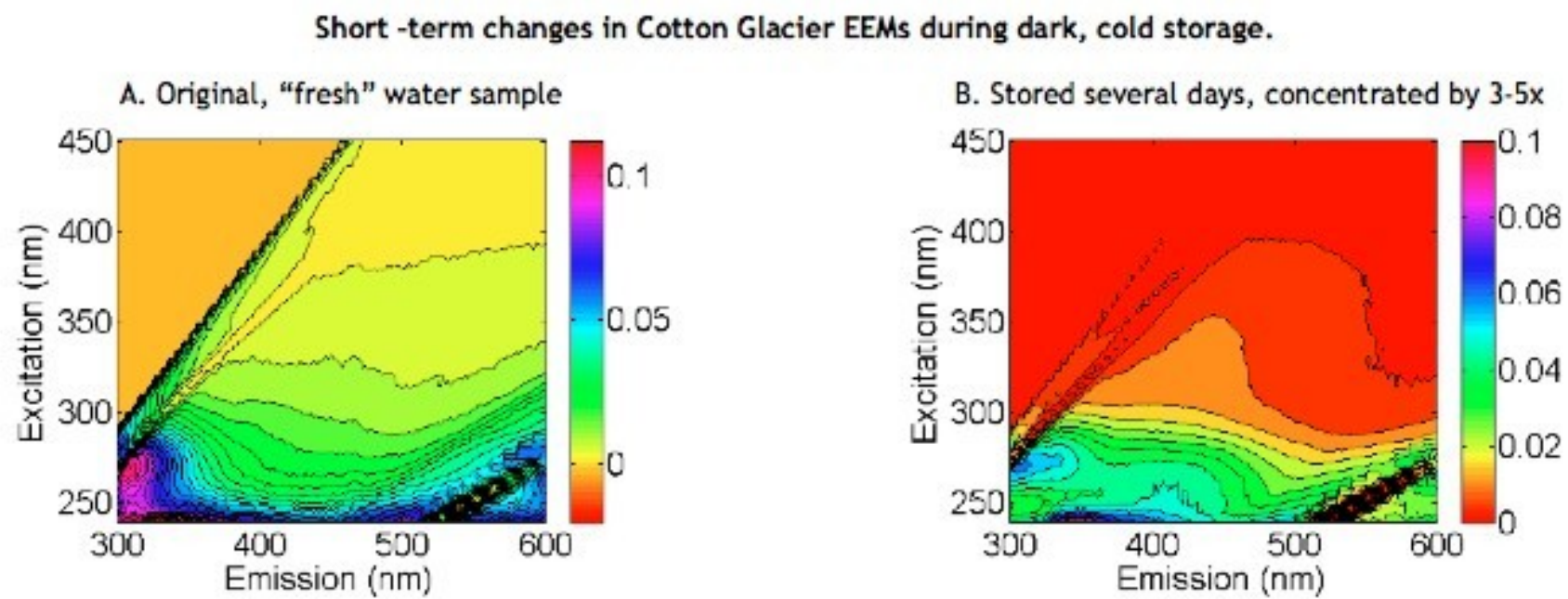
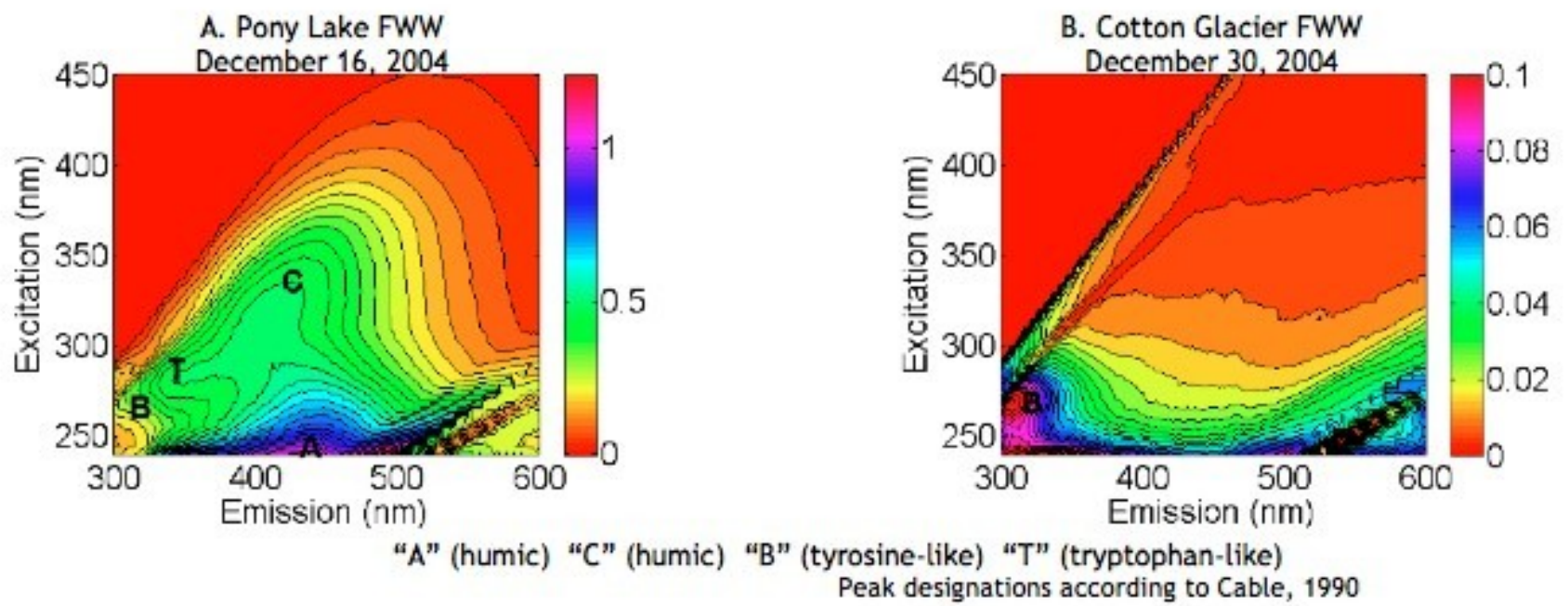


Figure 5. Top panel- Excitation emission matrices (EEMs) from Pony Lake (Cape Royds) and the Cotton Glacier. Components A and C are thought to be associated with the fulvic and humic fractions of DOM, while peaks B (tyrosine-like) and T (tryptophan-like) are referred to as the amino acid region. Note the absence of A & C regions from the fresh CG sample.

Bottom Panel- Cotton Glacier fresh (A) and aged (B) samples. Loss of intensity is observed in the amino acid regions (B and T) and gain in intensity is observed in the humic region (A and C). Fluorescence spectroscopy of DOM from this stream showed that it lacked humic signatures (Fig. 5), unlike DOM typical of microbially-based ecosystems. Analysis of the EEMs by PARAFAC indicated that amino-acid fluorophores dominate, which is consistent with DOM of microbial origin. These results indicate that DOM in this system is seasonally formed from soluble microbial products and that a reservoir of recalcitrant humified DOM does not pre-exist. After storage of the streamwater in the dark for 7 days, humic peaks were detected in the EEMs, suggesting that it can undergo humification

DISCUSSION

We examined the chemical characteristics of the DOM and the microbial assemblage of a remote supraglacial stream system that forms seasonally on the Cotton Glacier in the Transantarctic Mountains. Fluorescence spectroscopy was used to characterize the DOM in the stream, and gain insight into the formation of humic DOM from precursor microbial products. Microbial abundance, activity and community structure were also investigated in conjunction with the geochemical characterization of the site to understand how the microbial ecology is influenced by the DOM, especially in the absence of humic DOM and its ability to screen organisms from the harmful effects of UV radiation. Supraglacial streams may offer clues to environmental requirements for growth of microbes adapted to such extremely transient and humic-free conditions, as well as being capable of surviving long-range transport to the glacial surface. Given the ubiquity of humic substances and their distinctive fluorophores, it is exceedingly rare to observe a fluorescence signature of DOM that lacks a contribution from humic material. The Cotton Glacier fluvial water contained DOM with fluorescence characteristics unlike any present in other freshwater or marine systems globally, including the other studied streams and lakes in the McMurdo Dry Valley of Antarctica. During the 2009-2010 Antarctic field season, the DOM team is participating in the NSF-funded PolarTREC program. PolarTREC is an educational research experience, managed by the Arctic Research Consortium of the U.S. (ARCUS), in which K-12 educators join teams of scientists conducting research in the Polar Regions. The primary responsibilities of a PolarTREC educator are to participate as a full member of the research team, and to communicate information about Polar science, history, and culture with students, other educators, and Polar enthusiasts of all ages and backgrounds. To check out the adventures of the DOM team and Sarah Diers' journals go to:

www.polartrec.com/dissolved-organic-matter-in-antarctica.



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